

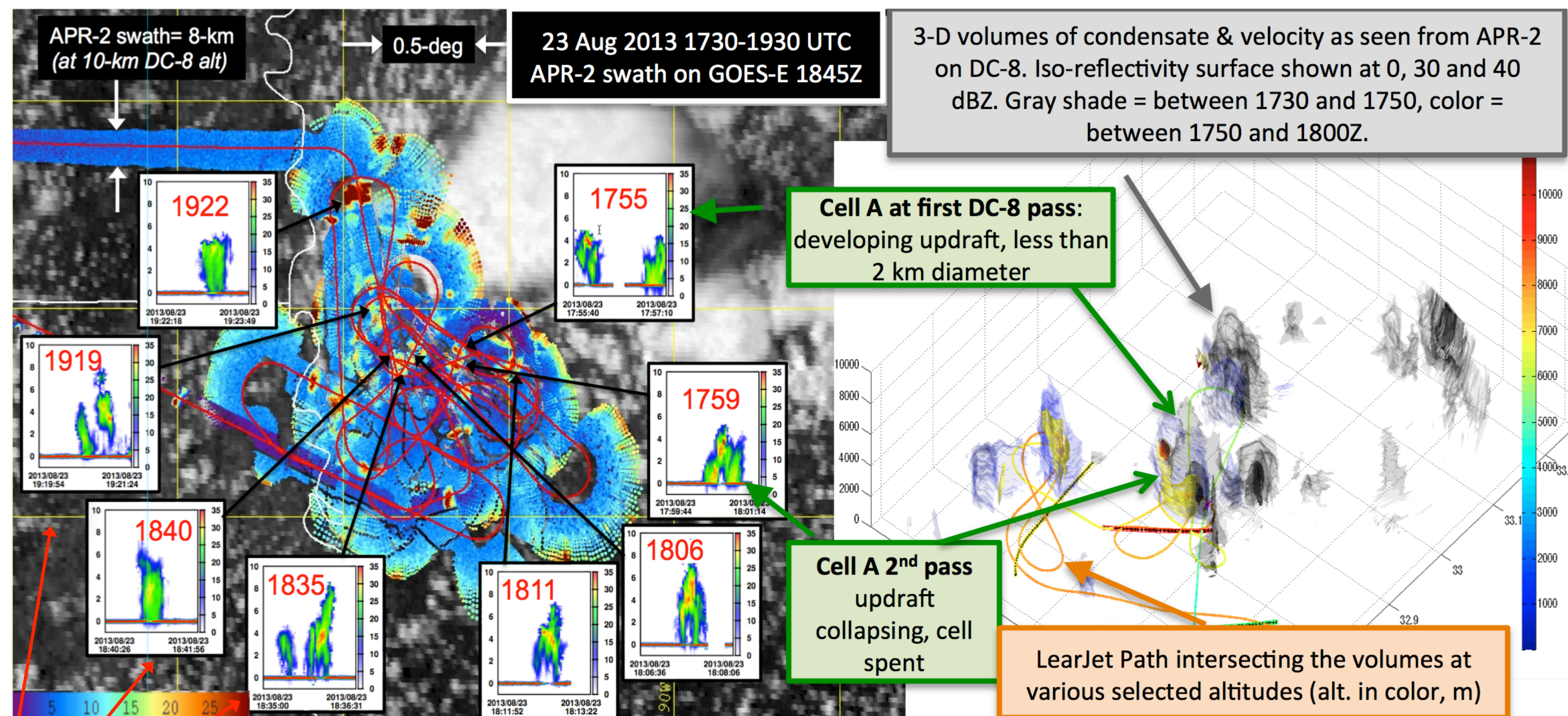
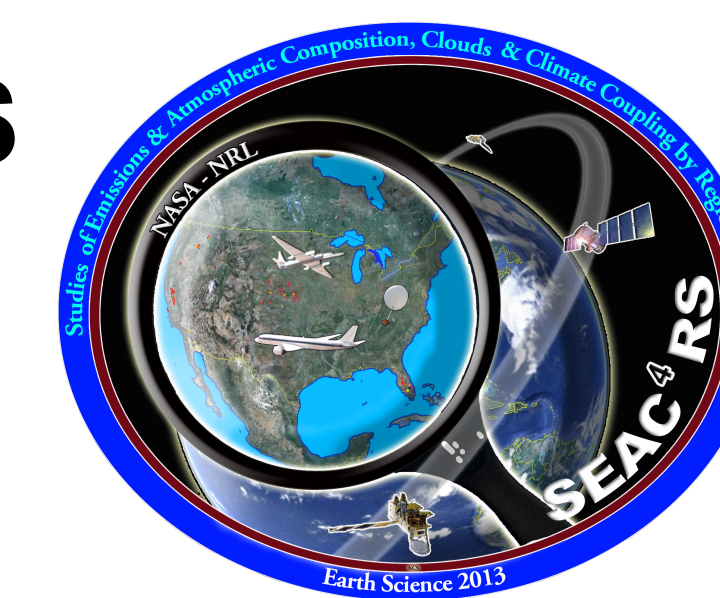
BACKGROUND

Convective clouds play a critical role in the vertical and horizontal transport and redistribution of energy, water vapor, aerosols, trace gases and momentum in the atmosphere. Vertical motion and microphysical processes are fundamental to the formation and development of convective clouds, and yet it is the representation of these very processes, and the feedbacks between them, that appears to produce the greatest disparities between models and observations of convective cloud systems. NASA's Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC⁴RS) field campaign provided an unprecedented observational laboratory for a focused investigation of cloud modeling issues and their interplay with the distribution and transport of atmospheric constituents. Based out of Ellington Field, TX, this long duration campaign provided many flights where the growth stages of cumulus congestus and cumulonimbus development were captured from repeated, coordinated observations between the JPL dual-frequency (Ku/Ka-band, 13.8 and 35.6 GHz), Doppler Airborne Precipitation Radar 2nd Generation (APR-2) onboard the NASA DC-8, and a SPEC, Inc. LearJet. Both aircraft were instrumented with SPEC optical array cloud and precipitation particle measuring systems, enabling direct in-situ measurement of the cloud particle size distribution.



Ku/Ka-band Airborne Precipitation Radar (APR-2) Measurements and Retrievals during SEAC⁴RS

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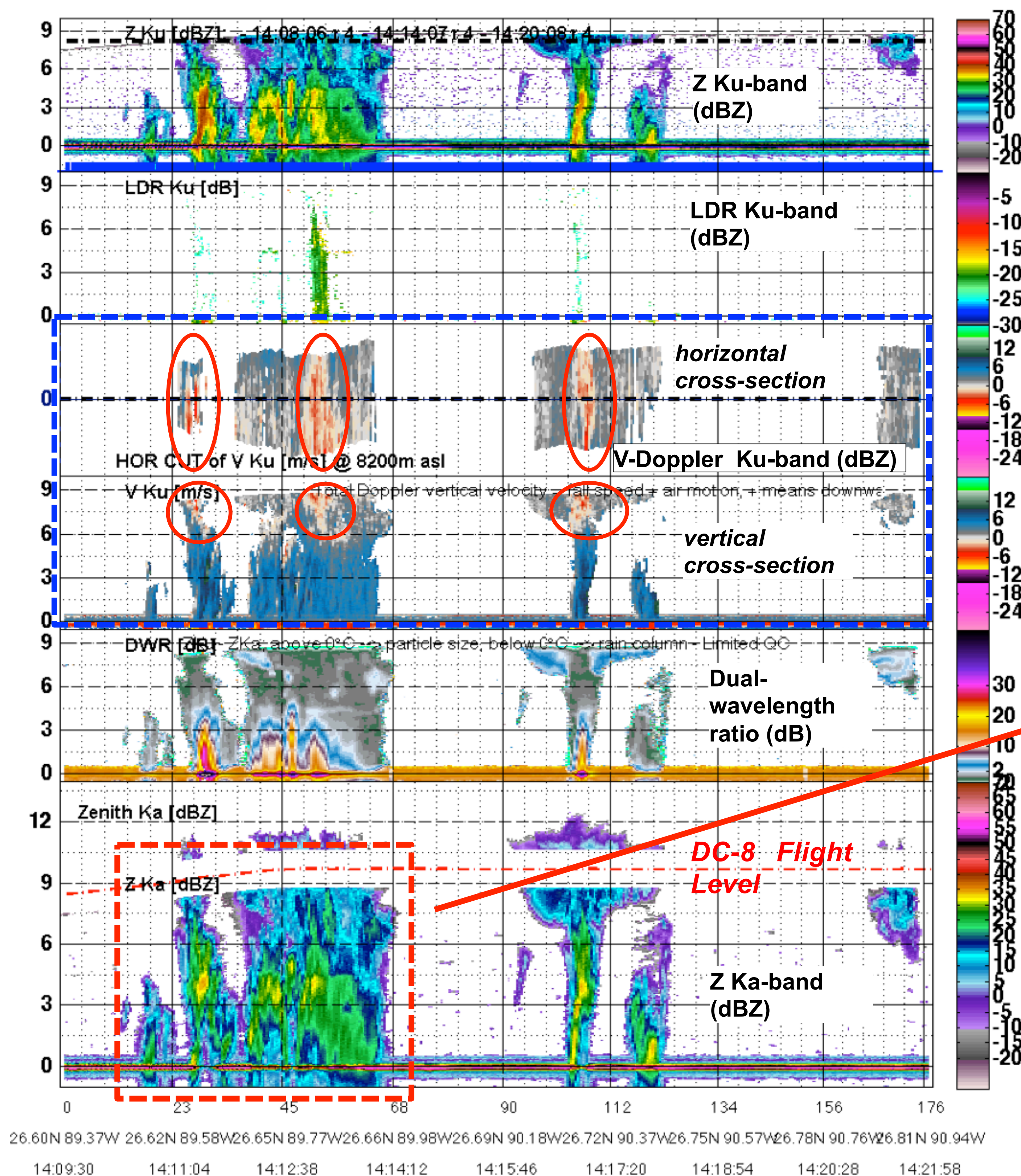


In several flight segments, the LearJet was positioned such that its optical probes sampled within the same cloud volume illuminated by APR-2. In these cases, repeat overpasses with the APR-2 jointly captured the fine-scale vertical air motion and the vertical cloud and precipitation microphysical structure over the short (5-10 minutes) time period during which cumulus clouds were characterized by active growth above the boundary layer, but had not yet fully glaciated.

23 August 2013 Over-Land Isolated Convection

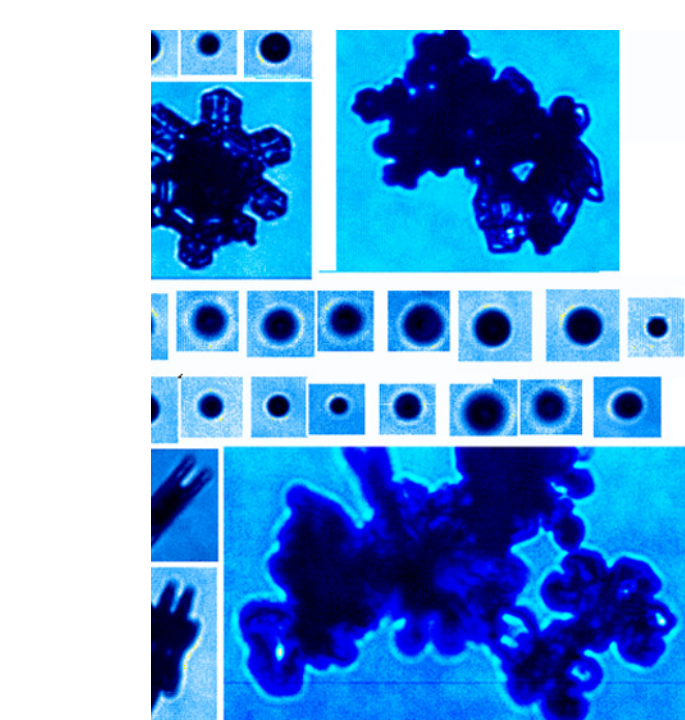
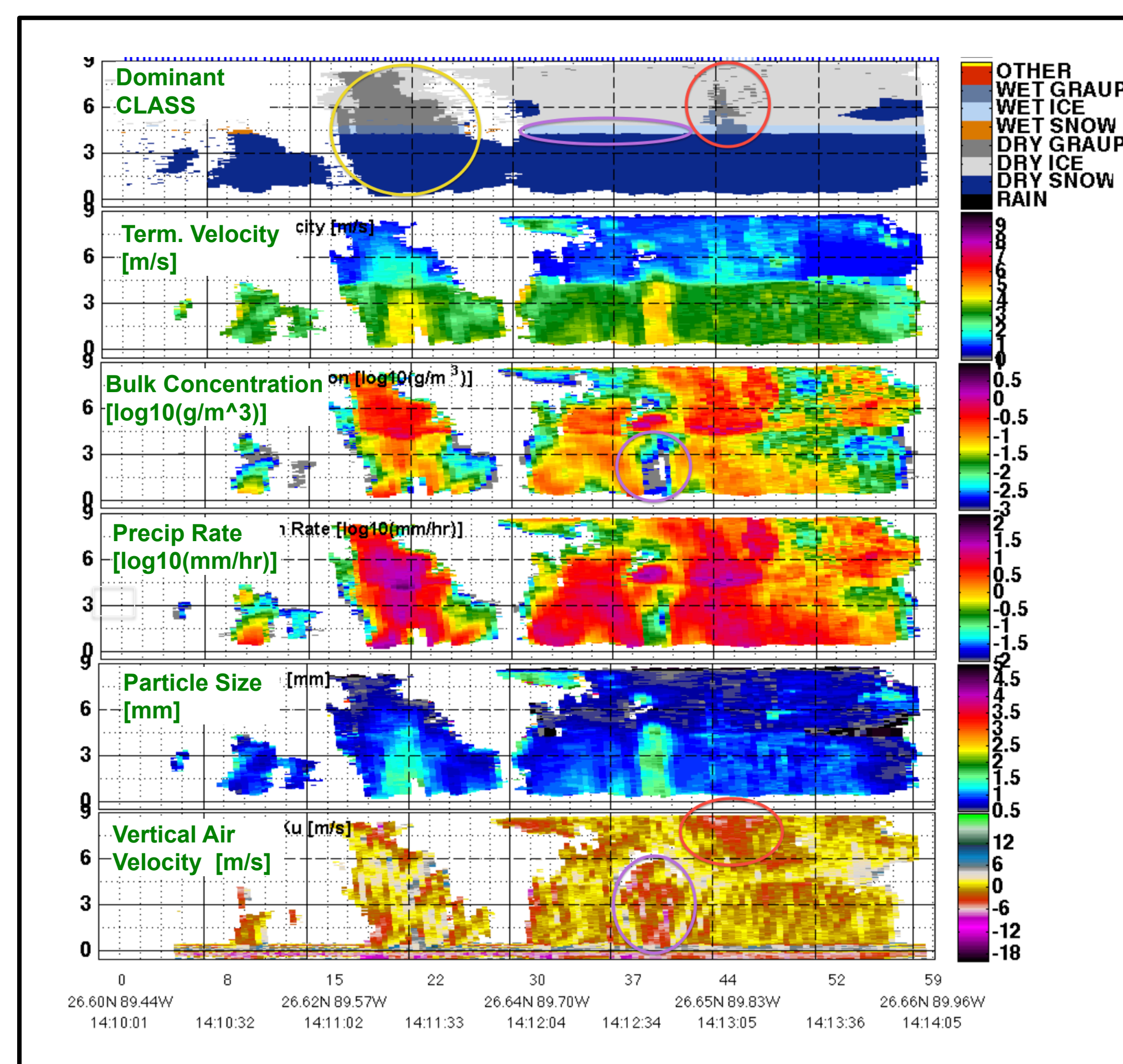
The DC-8 arrived near 1743Z at a location northwest of Jackson, MS to sample the air mass around convective weather in cooperation with the SPEC LearJet. The best cooperative work took place between 1845-1915 UTC, when the LearJet flew at a flight level below the DC-8, sampling the aerosol and cloud particles in the lower, rising area, while the APR-2 scanned downward to capture the vertical air motion and the overall vertical cloud structure. These joint observations provide an indication of the localized inner/outer cloud microphysical properties within the larger-scale cloud evolution. A variety of in-situ sensors on the DC-8 also sampled a multitude of chemical tracers such as methane and CO, which can give an indication of the origin of the air mass vertical transport.

Sequence of 90-second (50 APR-2 scans)
Ka-band profiles from nadir-pointing beam



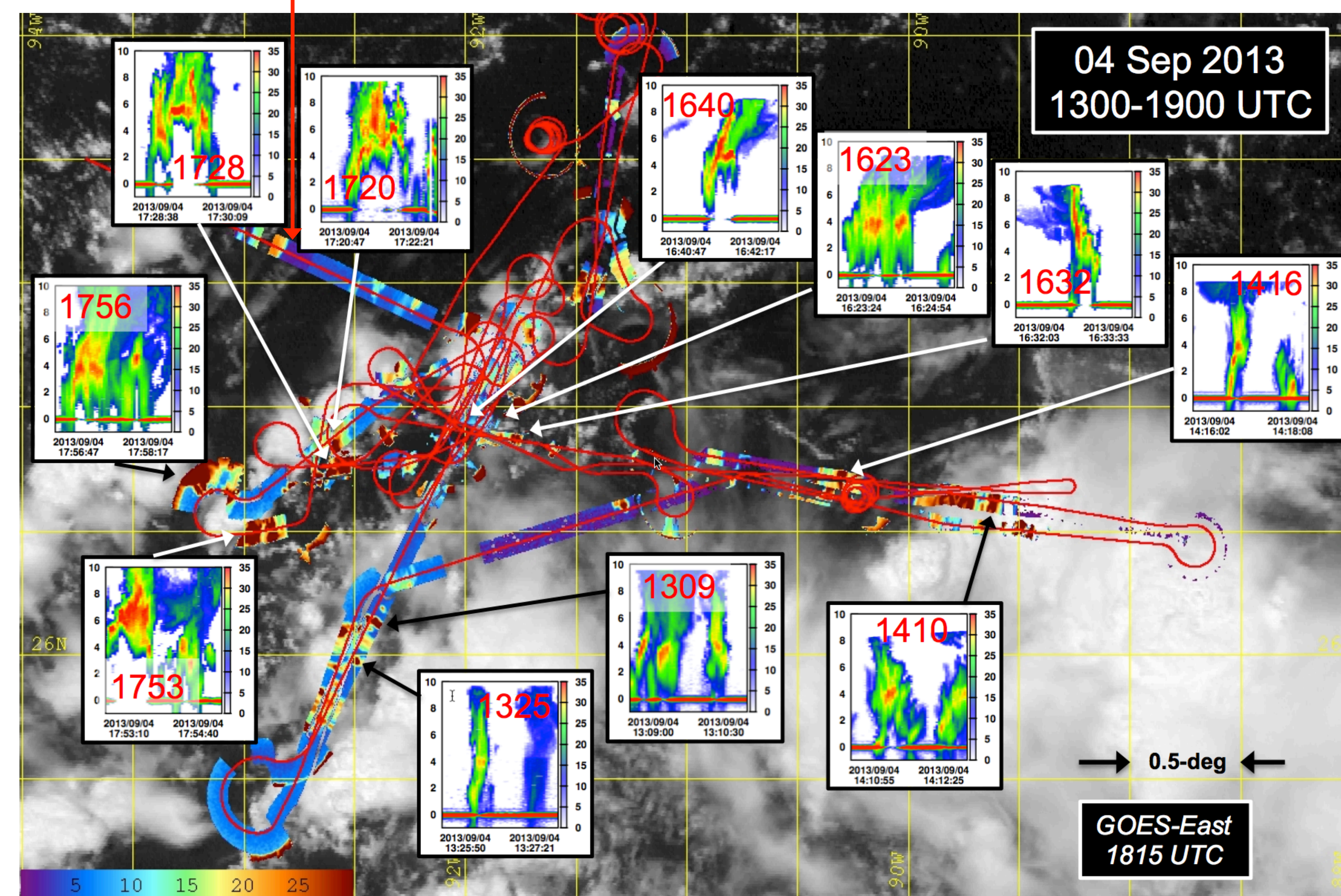
4 September 2013 Over-Ocean Isolated Convection

This flight took place over the Gulf of Mexico, southeast of Houston. The relatively short ferry to the on-station location allowed for nearly six hours of coordinated aircraft overpasses. These over-ocean flights involved more maritime convective processes over the warm Gulf of Mexico waters.



SPEC in-situ probes on DC-8
showing ice aggregates
(equivalent on LearJet)

From a 10-km flight altitude, APR-2 scan swath is \approx 8-km, with 37-m vertical resolution



APR-2 Suite of Processing and Retrieval Algorithms (ASPRA)

Expanded view of APR-2 data from the Sept. 4 flight between 1410-1422 UTC, showing a selection of APR-2 Level 1 (left) and Level 2 (right) products, and an example of SPEC samples gathered in-situ. All APR-2 products are produced by ASPRA, L1 are produced in quasi real time (revised post-campaign to refine calibration), and L2 are produced post-campaign. While all algorithms are fully automated, the L2 production requires a significant amount of attention to ensure quality and correct interpretation. Uncertainties are also produced (not shown). The 3-D nature of the observations enables full sizing of the cloud system features as shown above in the Doppler product in both in the typical vertical curtain and an horizontal section at 8.2 km AGL, the red ellipses highlight the dimensions of the three updrafts. Even when the LearJet was not flying in coordination with DC-8, in-situ samples were collected from the SPEC probes on DC-8 and the up-down looking geometry of APR-2 at Ka-band (lowest panel) enables correlation of those observations with the macroscopic cloud features.